Biological_control_Host_Finding

Host Finding and Semiochemicals

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Host Finding and Semiochemicals)

- The world is a big place.
- Now envision yourself as a wasp that is 0.1 mm long
- How do you find your host?
- Totally random searching is a quick route to extinction (except in rare cases)
- Insects use many types of cues in a multi-step process to locate hosts or prey.

HyperParasitoids

Predators Parasitoids

Pests phytophaga Prey host

Plants

Semiochemicals

SO THEY USE (RESPOND) TO Semiochemicals that they are chemical messengers.

Semiochemicals

- Semiochemicals are chemical messengers.
- They operate in one, two or three species systems.
- They function between individuals of the same or or different species, or between a non-living source and a living receiver.
- Semiochemicals can function as air-borne or contact stimuli.
- They can be used directly for pest management, but *they are commonly important in the host finding process!!!!!!!!!!!!!*

1. Pheromone: Emitter and the receiver belong to the same species. Usually it is the female emit pheromone and male response to it. The result is mating.
2. Allelochemical: Emitter and the receiver belong to different species

Allelochemical substances

1. **Allomones,** Only the emitter has a profit (advantage, while the receiver has not any profit, or has a negative effect
2. **Kairomones,** Only the receiver has a profit (advantage, while the emitter has not any profit, or has a negative effect
3. **Synomones** **Both of them** emitter and receiver have a mutual profit

Semiochemicals

Thus, some definitions of classes of semiochemicals.

Category of Semiochemical	Impact of Semiochemical		
	Emitter	Receiver	Other
Intraspecific : Pheromones	+/0	+	
Interspecific: Allomones	**+**	**0/-**	
Kairomones	**-**	**+**	
Synomones	**+**	**+**	**-**
Non-living source: Apneumones	0	+	

Semiochemicals

Examples of Pheromones

Sex pheromone
commonly used to detect pests or in mating disruption
Aggregation pheromone
mass-attacking bark beetles, can be a used as a bait
Anti-aggregation pheromone
spruce beetle
Alarm pheromone
many species of gregarious insects, could be repellents
Epidietic pheromone
marks exploited resource, could be repellents

Pheromones may be used as kairomones by natural enemies.

Semiochemicals

Examples of Allomones

Defensive secretions to deter would be predators

common, e. g. skatole of *Chrysopa* spp.

Chemical mimicry

some myrmecophiles chemically mimic their ant hosts
to avoid attack

bola spider mimics sex pheromone of female noctuids
to lure males within range for capture

Aggressive or Prey Subduction Allomone

rare, used to subdue prey, *Lomamyia*

Allomones may be used as kairomones by natural enemies.

Semiochemicals

Examples of Kairomones

- Chemical secretion that is used to the **benefit of a heterospecific receiver** in a two-species interaction.
- Host plant odors attract many herbivores

Semiochemicals

Examples of Kairomones STUDENTS

- Females of the green lacewing *Chrysoperla plorabunda* are attracted to indole acetaldehyde a breakdown product of the amino acid tryptophan which occurs in aphid honeydew.

- Thus, the females can locate aphid infestations and deposit their eggs near a larval food source.

- Pheromones can be subverted (translated-recognized) by a predaceous species and used as kairomones.

Examples of Synomones

A secretion that is used to the benefit of the emitter and a heterospecific receiver, and to the detriment of a third species.

- Plant odors can be used by entomophaga to locate prey.
- Sinigrin a constituitive component in crucifers attracts the cabbage aphid, *Brevicoryne brassicae* (Kairomone), and its parasite *Diaeretiella rapae* (Synomone). (STUDENTS)

Semiochemicals

Examples of Synomones (students)

A more sophisticated system is seen with the beet armyworm, *Spodoptera exigua*, and its braconid parasite *Cotesia marginiventris.*

C. marginiventris responds to chemicals produced when caterpillar saliva interacts with plant chemicals.

This is more efficient for host location.

Cotesia marginiventris on *Spodoptera* larva

Host Finding

Host Finding

- Host finding is a highly variable, often complex process.
- Some extreme generalists do not search for hosts, e. g. some tropical walking ticks simply drop eggs wherever they are.
- This is a rare situation.

Host Finding (STUDENTS)

Most insects go through some or all of the following steps:

1. Host habitat finding
2. Host finding
3. Host acceptance
4. Host suitability
5. Host regulation

Host Finding 1. Host habitat finding

- This process can involve intrinsic preferences for a cue that indicates a general area that may support the host, or more specific cues (semiochemicals) that indicate a specific potential host habitat.
- Intrinsic habitat preferences are not well-known and often involve color cues.
- Many aphids are attracted to yellow, indicating the possible presence of plants. (Hence the utility of yellow pan traps.)
- Similarly, some green lacewings are attracted to green.

Host Finding

1. Host habitat finding

- An insect is attracted to cues more directly related to the presence of a host or prey. The host plant odor is a common cue
- Recall the cabbage aphid and its parasite *Diaeretiella rapae*, both are attracted to cruciferous plants by sinigrin.
- Host finding for the aphid, but ***host habitat finding for the wasp.***

Brevicoryne brassicae on canola

Diaeretiella rapae ovipositing in a cabbage aphid

Host Finding

1. Host habitat finding

- Host pheromones are often taken over as kairomones by entomophages.
- Aphid alarm pheromones are released from the cornicles in a viscous liquid and can be quite effective against small, parasitic wasps, e. g. *D. rapae*.
- Some large coccinellid beetles use the alarm pheromone as a kairomone to locate their prey.

*A*n ovipositing wasp elicits alarm pheromone release from an aphid.

A coccinellid is attracted to the odor of the alarm pheromone.

Host Finding

1. Host habitat finding

2. Host finding
    - Chemical cues
    - Sound and Vibration
    - Sight and Movement

2. Host acceptance
3. Host suitability
4. Host regulation

- **Host finding** can be a continuation of **host habitat finding,** e. g. the clerids mentioned earlier or it may involve different cues.
- Host food plant damage is used by many parasitoids.
- *Cotesia marginiventris* being attracted to the beet armyworm by chemicals produced when caterpillar saliva interacts with plant compounds.

Cotesia marginiventris on *Spodoptera* larva

Host finding can involve contact pheromones, less volatile chemical compounds that are perceived on contact.

Trichogramma spp. (Hymenoptera: Trichogrammatidae) respond to trichosane rubbed on the plant surface from the wing scales of adult moths as they oviposit.

Trichogramma sp. antennating moth eggs

Sound and Vibration:

Vibrations are used by several parasites that attack endophytophagous hosts, e. g.
Opius (now *Biosteres*) spp. that attack fruit fly (Tephritidae) larvae in fruit.

Host Finding

Sight and Movement:

Perilitus sp.

Perilitus spp. (Hymenoptera: Braconidae) locate their adult beetle hosts by color and movement.

Host Finding

1. Host habitat finding
2. Host finding

3. Host acceptance

3. Host suitability
4. Host regulation

Host Finding 3.Host acceptance

- Having located a potential host some insects, especially parasitic Hymenoptera, assess the host for probable suitability before ovipositing.
- This preliminary check reduces the risk of wasting eggs on/in an unsuitable host. Many types of cues are used.
- Thus, it is logical that this behavior is more common in more host-specific natural enemies and those that need to avoid intrinsic competition.
- Greater host specificity is one of the main reasons that host assessment is more common in Hymenoptera.

Host Finding **3.**Host acceptance

1. Contact kairomones are very important in host acceptance.
2. Texture
3. Size
4. Stage of development
5. Parasitized/Not Parasitized

Host Finding **3.**Host acceptance

Texture:

- *Nasonia* spp. (Hymenoptera: Pteromalidae) parasitize muscoid fly pupae. The host range of a specific species is limited, e. g. some species prefer muscid hosts other attack calliphorids.

- One of the ways they discriminate between more and less suitable hosts is the surface texture of the puparium.

Nasonia sp. antennating the surface of a fly puparium

Host Finding 3.Host acceptance

Size:

Aphelinidae parasitizing
a scale insect

- Chalcidoid parasitoids of scales (Encyrtidae and Aphelinidae) reject scales that are too small to permit larval development.(This is a common phenomenon among parasites.)
- Species that can control fertilization of the egg will deposit 1N (male) eggs in small scales (sperm is small and cheap).
- They will deposit 2N (female) eggs in larger scales to optimize fecundity of female offspring (eggs large and costly).

Question:

Why Chalcidoid parasites of scales (Encyrtidae and Aphelinidae) reject scales that are too small??????

Answer

- Parasitoid larvae can not develop in scales that they are too small (lack of sufficient food)

Host Finding **3.**Host acceptance

Size:

- Gregarious parasites can also use host size to determine the number of eggs to deposit in any given host.
- *Trichogramma* spp. are known to deposit from 1 to 50 eggs in a host egg, depending of the size of the host egg.
- This is a very efficient way to optimize host utilization.

Trichogramma assessing moth eggs

Stage of development:

This is obviously an important characteristic of the host, thus we define egg parasites, larval parasites, etc.

Consider an holometabolous host:

eggs, larvae, pupae and adults may not co-occur in space or time

the four life stages are anatomically and physiologically different

Stage of development:

However, finer constraints are known for some parasites.

Pteromalus puparium (Pteromalidae) attacking only very young cabbage butterfly pupae, before the cuticle hardens so its ovipositor can penetrate the host.

Similarly, but for physiological reasons, *Trichogramma* spp. attack only recently deposited eggs in the early stages of embryogenesis to avoid the developing host's immune system (encapsulation)

Question:

Why *Trichogramma* spp. attack only recently deposited eggs in the early stages of embryogenesis

Answer

to avoid the developing host’s immune system (encapsulation)

Host Finding **3.** Host acceptance

Parasitized/Not Parasitized:

This question is critical to obligatory primary parasites and many obligatory secondary parasites.

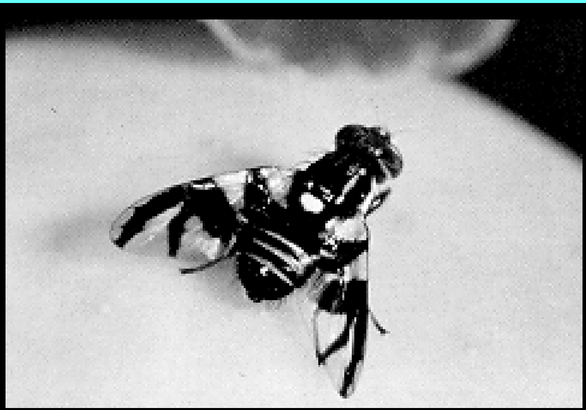
Progeny could die due to intrinsic competition (1° parasite) or lack of intermediate host (2° parasite).

Hymenoptera have the best systems for assessment, usually using sensors on their ovipositor to refine the assessment.

Host Finding

3.Host acceptance

Parasitized/Not Parasitized:



Snowberry maggot marking fruit

Some insects leave external markers (epidietic pheromones) to deter later attack.

Rhagoletis spp. (Diptera: Tephritidae) mark their oviposition site in the fruit with such a pheromone.

Trissolcus basalis (Hymenoptera: Scelionidae) makes a figure-8 with its ovipositor on the pentatomid eggs it has parasitized to leave its epidietic pheromone.

Host Finding

1. Host habitat finding
2. Host finding
3. Host acceptance

4. Host suitability

4. Host regulation

Host Finding   **4.** Host suitability

- Host suitability can only be evaluated as the successful emergence of viable progeny from the parasitized host.
- Despite the previous steps, not all parasite attacks are successful.
- The dominant factor in determining host suitability is usually the host's immune system.
- Hemocytes respond to non-self tissue and surround it to protect the insect from infection, etc.

This is also the primary defense against parasitism. It is termed encapsulation. The hemocytes cover the parasite, melanize and deprive the parasite egg or larva of oxygen.

Host Finding

1. Host habitat finding
2. Host finding
3. Host acceptance
4. Host suitability
5. Host regulation

Host Finding 4. Host regulation

- *Copidosoma* spp. (Hymenoptera: Encyrtidae) are gregarious parasites and are polyembryonic.
- They induce supernumerary molts in their Lepidoptera larvae hosts, producing larger hosts, increasing the number of wasps that will emerge from that host

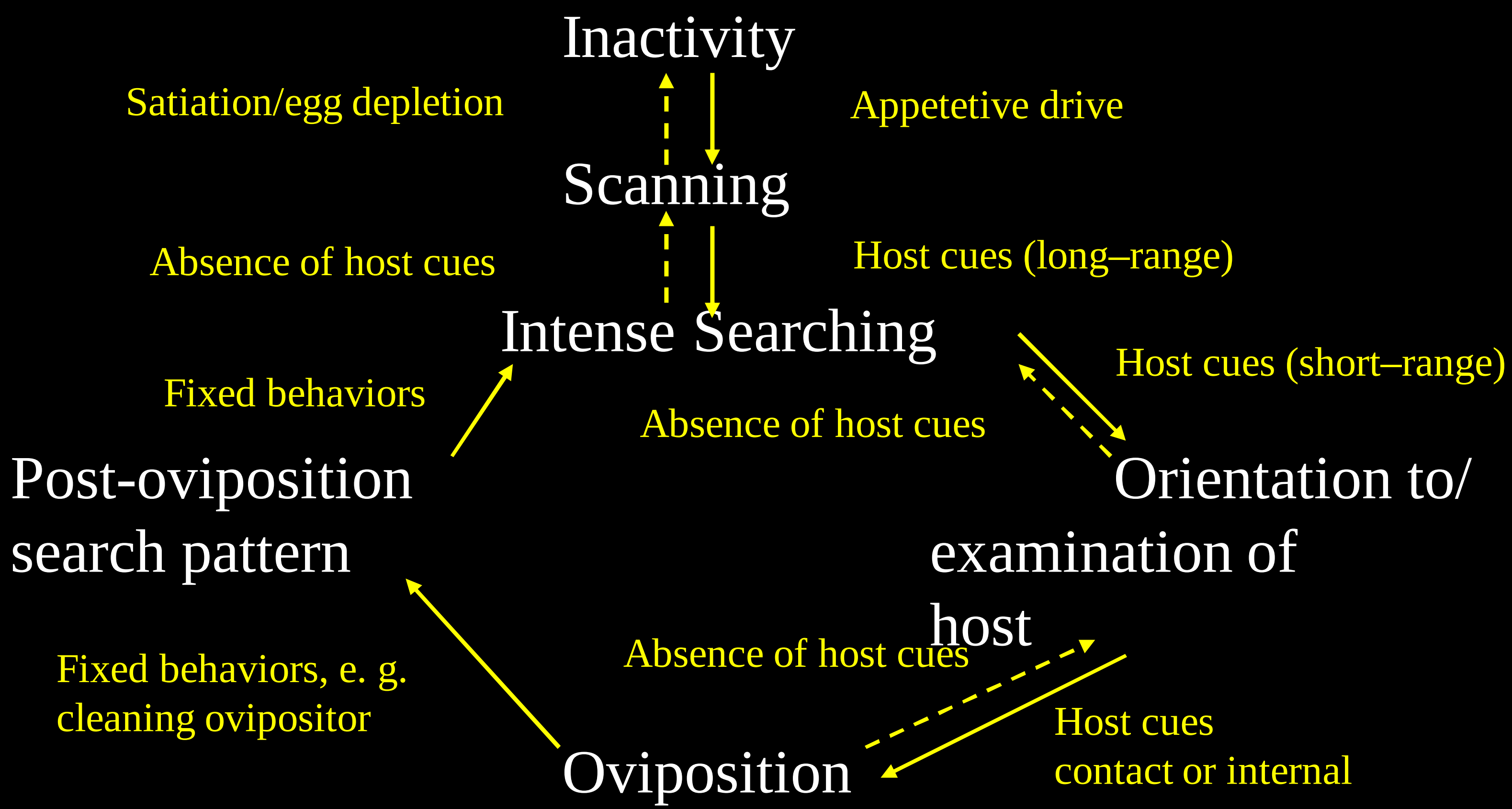
Copidosoma adult, 1 mm

Copidosoma, host with pupae

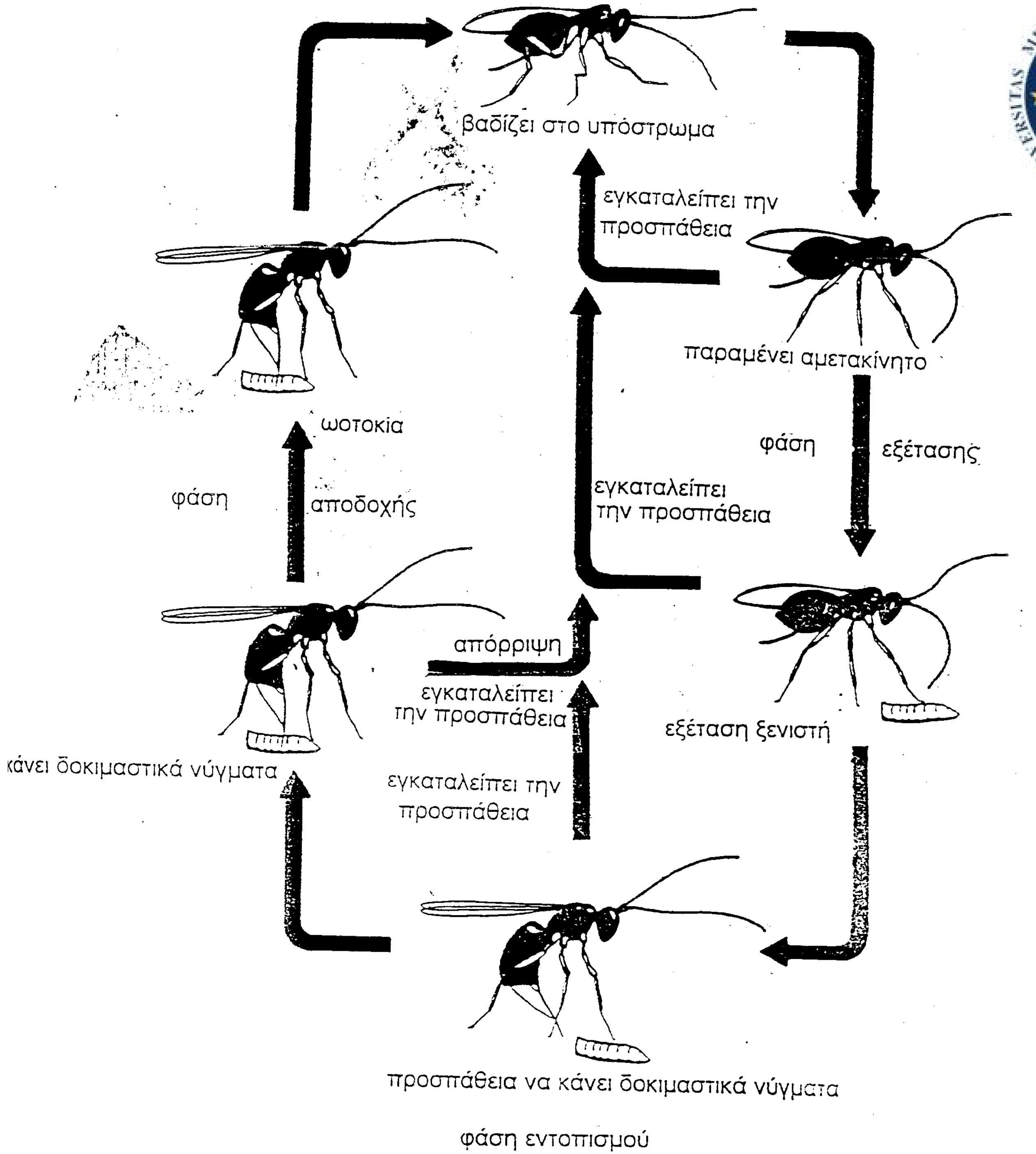
Copidosoma emerging

Host Finding (Pages 79-84)

Diagrammatic summary of host finding activities (Page 82)



See examples on pages 83 and 84.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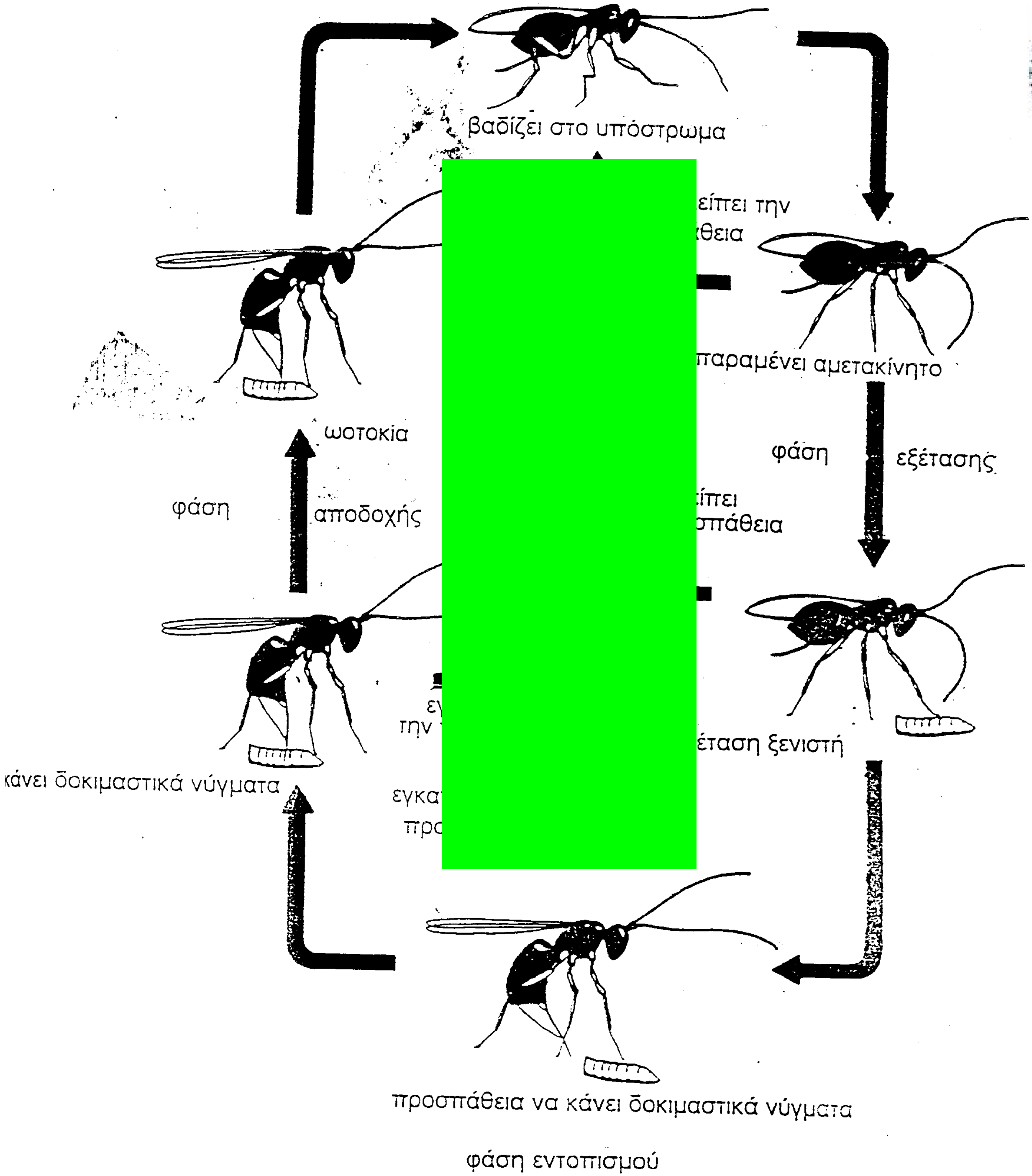

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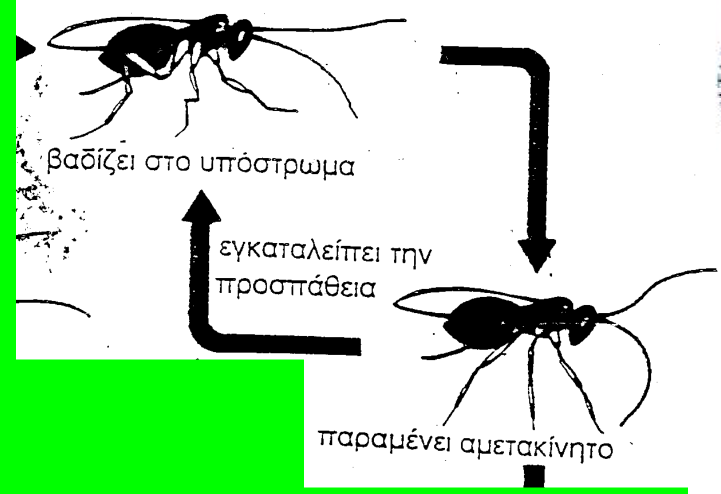

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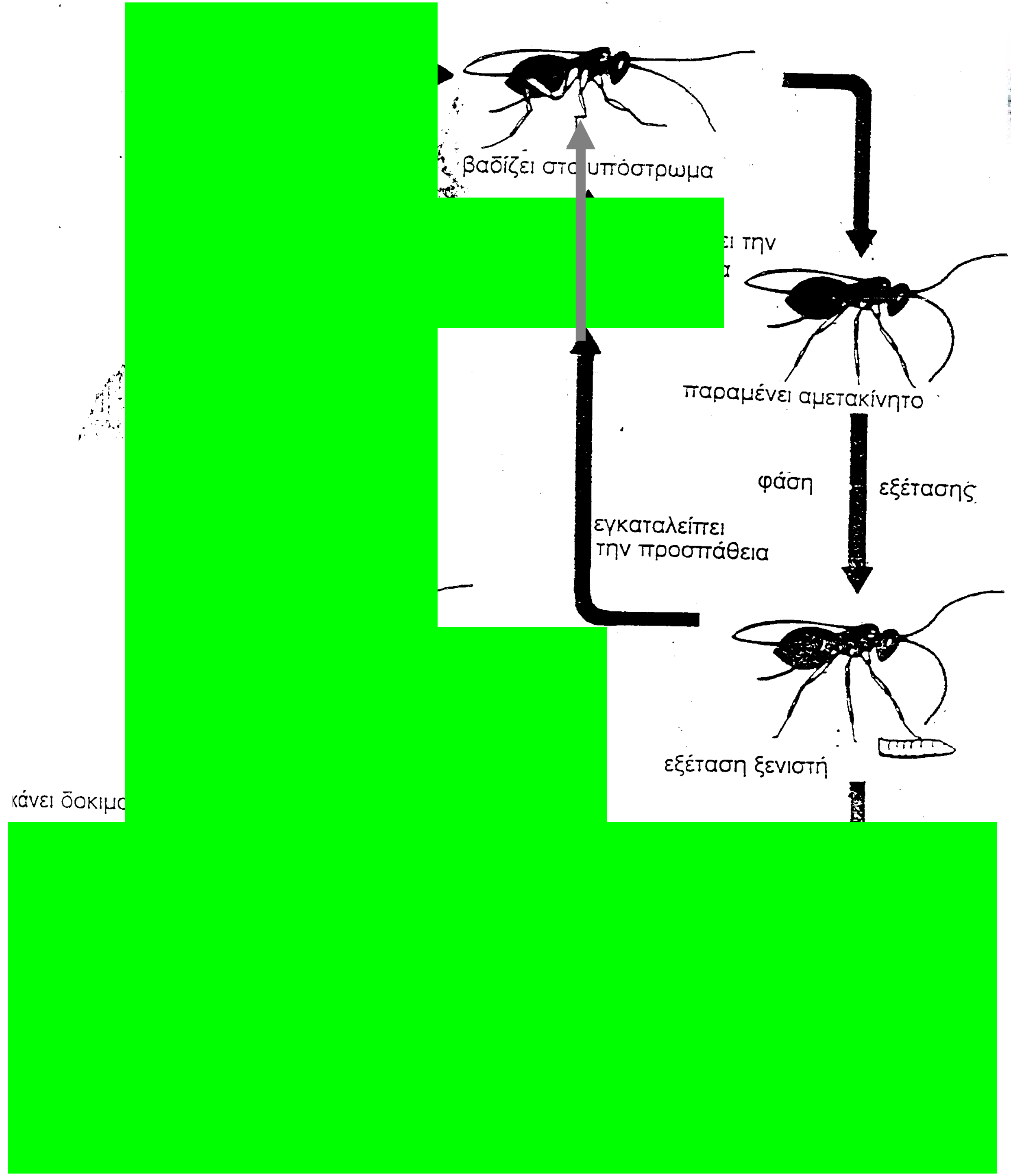

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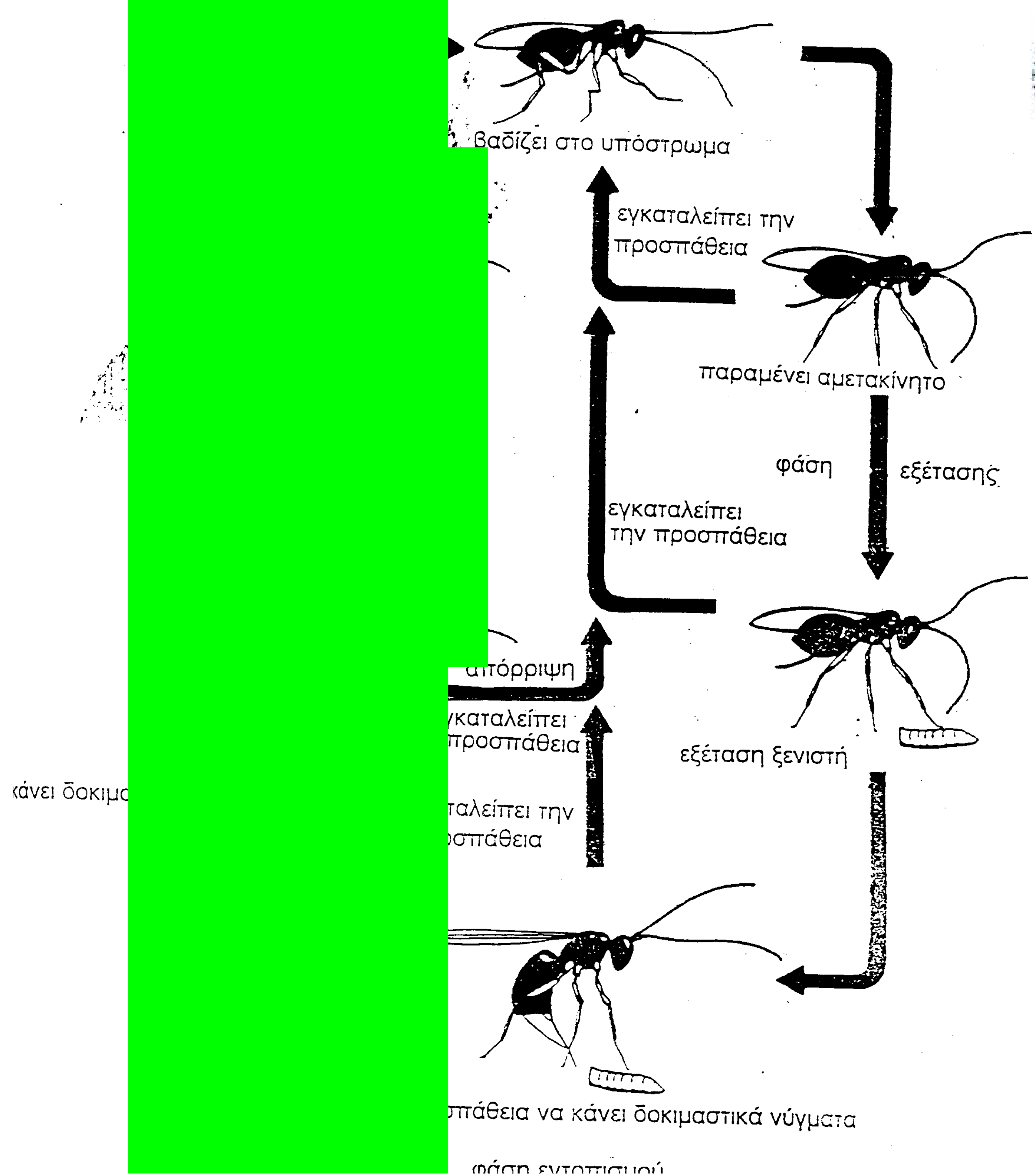

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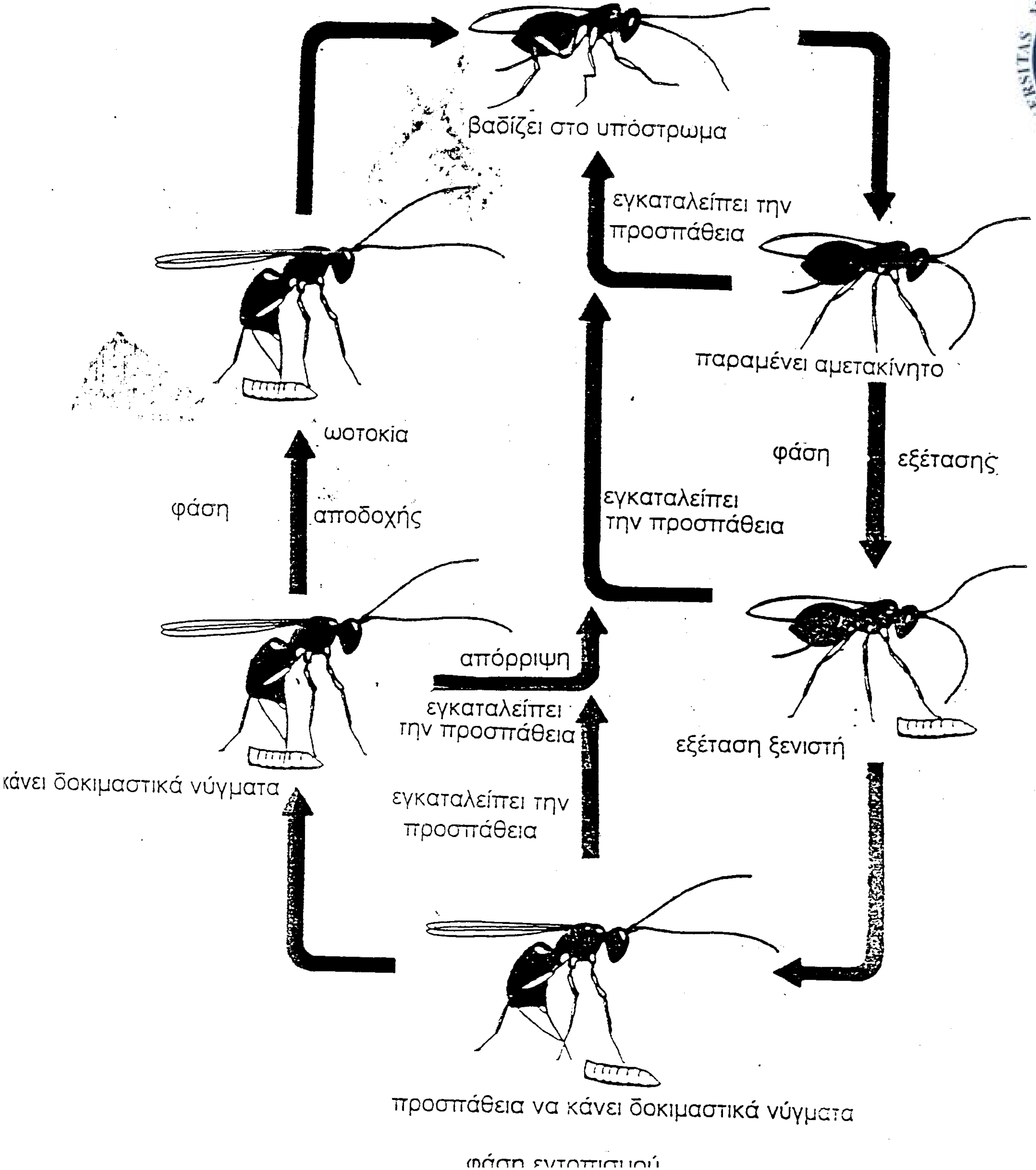
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φάση εντοπισμού

Host Finding

4. Host regulation

Some parasites take control of their host's development to optimize benefit to the parasite.

The parasite may delay or hasten host maturity, or even alter the number of instars host passes through to mature.

Aphidius platensis (Hymenoptera: Braconidae: Aphidiinae) slows development of its aphid host with secretions from its teratocytes (cells from embryonic membrane).

Syrphoctonus spp. (Hymenoptera: Ichneumonidae) accellerate development of their syrphid hosts. Yielding smaller hosts that the wasp larva can completely consume.

Semiochemicals

Examples of Synomones

- Similarly, caryophyllene is attractive to *Chrysoperla plorabunda*, indicating a possible source of aphids.
  This attraction interacts positively with the attraction to indole acetaldehyde.

Semiochemicals

Examples of Apneumones

Apneumones arise from non-living sources, so this is a one-way interaction that benefits the receiver.

Venturia canescens (Ichnemonidae) is attracted to oatmeal, whether or not its host, the Mediterranean flour moth, *Ephestia kuhniella* (Pyralidae), is present.

The chemical must not be due to the presence of the host, or it would be a kairomone.

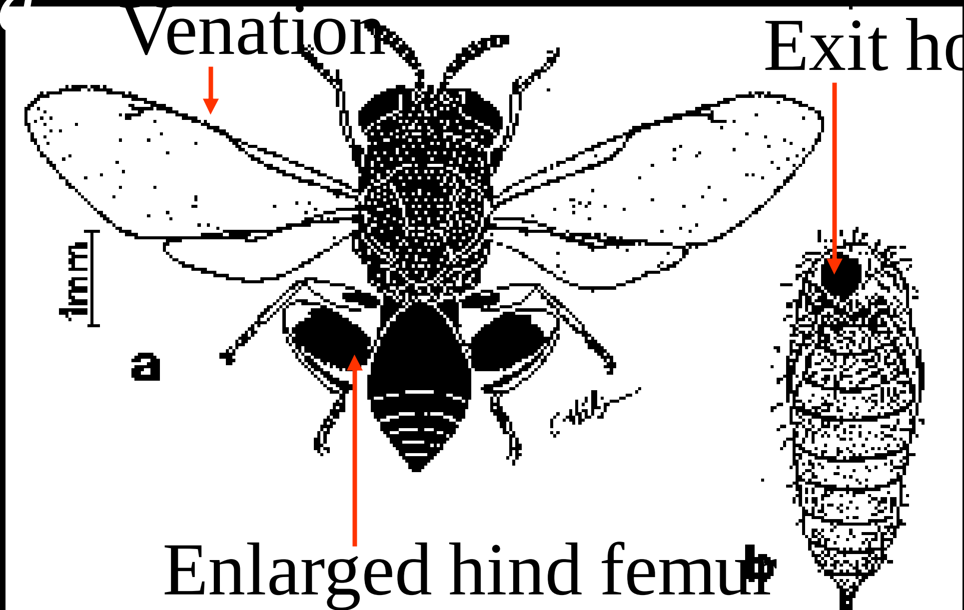
Host Finding

1. Host habitat finding

An unusual example involves *Brachymeria intermedia*, a chalcidid parasites of the gypsy moth.

B. intermedia is attracted to dappled light, as occurs at the edge of a forest or in defoliated areas.

Brachymeria intermedia
and gypsy moth pupa



Host Finding 1. Host habitat finding

Host/prey pheromones are also used by numerous predators and parasites of mass-attacking bark beetles.

This is well-known in clerid beetles, e. g. *Enoclerus* and *Thanasimus* spp.

Thanasimus formicarius on conifer bark